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原著　2

血中脂質・動脈硬化指数・身体組成・心肺持久性に及ぼすジョギングの影響

EFFECTS OF LONG DISTANCE JOGGING UPON BLOOD LIPIDS, ARTERIOSCLEROTIC INDICES, BODY COMPOSITION AND CARDIOVASCULAR ENDURANCE

戎　利光※・斎藤　由美※※・島田　政則※※※・松沢　甚三郎※※※※

Toshimitsu Ebisu, Ed.D.※
Yumi Saito※※
Masanori Shimada, M.D.※※※
Jinzaburou Matsuzawa※※※※

抄録

近年，ジョギングがブームであり，健康の為にジョギングを楽しんでいる人々が多い。ジョギングに見られる効果の一部としては，血中脂質・体脂肪の減少，呼吸循環機能の向上などがあるが，血中脂質への効用に関する研究では，アテローム性動脈硬化指数，動脈硬化指数，Atherogenic 指数やその他の血中指数に関する指数は，あまり分析されていない。従って，本研究の目的は，ジョギングが，動脈硬化に関連した上記指数を始め，その他の血中脂質，身体組成，さらに心肺持久性に及ぼす影響を明らかにすることである。

53名の健康な男子大学生が被験者となり，うち39名は，各個人の最高心拍数の80％をジョギング中維持し，週3日間の割合で10週間ジョギングに取り組んだ。他の14名は対照群であり，10週間の実験期間中，特に運動をしなかった。本研究で分析した項目は，血中脂質として，総コレステロール（TC），総トリグリセライド，高比重リポ蛋白コレステロール（HDL），低比重リポ蛋白コレステロール，超低比重リポ蛋白コレステロール，前記三動脈硬化指数及び HDL/TC，身体組成として，体脂肪率（% Fat），体脂肪，除脂肪体重，体重，心肺持久性として，最大酸素摂取量（$\dot{V}O_2$ max），最高心拍数（max HR），1.5マイル（約2.4km）走タイムであった。

本研究により，HDL，アテローム性動脈硬化指数，HDL/TC，$\dot{V}O_2$ max が有意な増加を示し，動脈硬化指数，% Fat，max HR，1.5マイル（約2.4km）走タイムが有意な減少を示した。

※福井大学教育学部　Faculty of Education, Fukui University
※※名古屋造形芸術短期大学　Nagoya Junior College of Creative Art
※※※福井総合病院内科　Internal Department, Fukui Hospital
※※※※福井医科大学医学部　School of Medicine, Fukui Medical University

ABSTRACT

A jogging boom is on and lots of people are jogging for health. Some of the effects of jogging are to be a decrease in blood lipids and body fat and an improvement in cardiovascular function. But in research studies on these effects, the atherosclerotic, arteriosclerosis, and atherogenic indices and one other blood lipid ratio are not frequently analyzed. Therefore, the purpose of this study is to clarify the effects of long distance jogging upon blood lipids, body composition, and cardiovascular endurance including the above indices and blood lipid ratio.

Fifty three untrained male college students were used as subjects. The experimental group including 39 subjects jogged three days a week for 10 weeks with training intensities at 80 percent of each subject's maximal heart rate (max HR). The control group consisted of the other 14 subjects who did not perform any additional physical activity for the 10 weeks. All members of the experimental group ran two miles (approx. 3.2km) a day for the first three weeks, four miles (approx. 6.4km) a day for the following three weeks and finally six miles (approx. 9.6km) a day for the last four weeks. Variables determined in this study were : blood lipids ; total cholesterol (TC), total triglyceride (TG), high density lipoprotein cholesterol (HDL), low density lipoprotein cholesterol (LDL), very low density lipoprotein cholesterol (VLDL), HDL/LDL (called the atherosclerotic index)[38], (TC-HDL)/HDL (called the arteriosclerotic index)[12], LDL-HDL (called the atherogenic index)[22] and HDL/TC, body composition ; percent body fat (%Fat), body fat (Fat), lean body mass (LBM) and body weight and cardiovascular endurance ; maximum oxygen consumption ($\dot{V}O_2$ max), max HR and 1.5 mile (approx. 2.4km) running time (1.5 mile run). This study found that HDL, HDL/LDL, HDL/TC and $\dot{V}O_2$ max increased significantly and (TC-HDL)/HDL, %Fat, max HR and 1.5 mile run decreased significantly.

INTRODUCTION

A jogging boom is on and lots of people are jogging for health. Some of the effects of jogging are decreases in blood lipids and body fat and improvement in cardiovascular function. There are many studies[3,8,9,11,16,17,18,23,25,27,30,31,35,36,37] concerning chronic effects of exercise upon blood lipids. However, these studies revealed contradictions on the effects. In other words, some studies[3,11,16,27] have shown significant changes in blood lipids due to chronic exercise whereas there are some studies[23,25,35,36] which have shown no significant changes. Concerning the contradiction, Cooper[7] has indicated that one of the ways to lower cholesterol appears to be through exercise. He also indicated that the reason why he used the word "appear" is that whether this lowered cholesterol level is sustained for a long period of time, and for how long, is still open to question.

As Cooper[7] indicated, effects of chronic exercise upon blood lipids depend upon how long the exercise was engaged. Also effects seem to depend upon type, frequency, duration and intensity of exercise. In research studies by Pollock et al.[27] and Webster et al.[37] which showed a significant decrease in blood lipids, subjects exercised two or four days a week for 16 weeks, and 45 minutes a day, three days a week for 12 weeks, respectively. In Golding's study[11] which showed a significant decrease in TC, subjects engaged in a severe endurance program for 25 weeks. On the other hand, in a study by Terjung and others[36] which showed no significant changes in triglyceride, subjects performed running-in-place for six minutes twice a day for only six weeks.

Effects of chronic exercise also depend upon blood lipid levels prior to the exercise. Individuals who are high in blood lipid levels seem to be greatly effected by an exercise program. Roundy et al.[31] indicated by their study that exercise proved to be effective in relieving abnormal serum lipid conditions in subjects with types II

and Ⅳ hyperlipoproteinemia and in causing a favorable shift in lipoprotein densities from lighter density, VLDL and LDL, to heavier density, HDL. They investigated the effects of 10 week continuous walking and jogging performed three times a week.

Dietary intake is also one of the factors which influence blood lipids. Balart et al.[3] found a significantly negative correlation between caloric intake and serum cholesterol. They also stated that there was a significantly negative correlation between physical activity index and triglycerides, indicating that the lack of physical activity may be the major factor determining hypertriglyceridemia. Campbell[4] also stated that physical activity is a stronger determinant than diet of serum cholesterol level.

The contradiction previously mentioned seems to exist on body composition also. Ismail[13] and Milesis et al.[24] reported significant effects whereas McGuiness and Sloan[21] and Terjung et al.[36] reported no significant effects. To solve the contradiction, the American College of Sports Medicine[1] indicated that some programs with less participation generally show little or no change in body composition. In other words, a research study which shows a significant change in body composition is supposed to be conducted by using longer training in duration, frequency, and over a longer period.

Concerning improvement of $\dot{V}O_2$ max, many research studies have been conducted. Milesis et al.[24] found that improvement in $\dot{V}O_2$ max was proportinal to duration of the training session with a running program of intensity of 85 to 90 percent max HR for 20 weeks. Improvement of $\dot{V}O_2$ max is, however, dependent upon individuals' fitness levels and other factors. Depending upon the quantity and quality of training, improvement in $\dot{V}O_2$ ranges from five to 25 percent according to the American College of Sports Medicine.[1] Although changes in $\dot{V}O_2$ max greater than 25 percent have been shown, they are usually associated with large total body mass and fat weight loss, or a low initial level of fitness.[1,5] Carter et al. agreed with the American College of Sports Medicine by conducting a two year research study. As a general conclusion, Lamb[15] indicated that some improvement in $\dot{V}O_2$ max can be expected if [1] the exercise intensity is at least that required to bring the heart rate above 130 bpm, [2] the duration of each exercise period at this intensity is at least 10 min. besides warm up time, and [3] the frequency of training at least three times per week. Concerning max HR, as Scheuer and Tipton[33] explained, some previous studies[14,20,26,28] showed decreases due to chronic exercise.

Since contradictory research reports on blood lipids, body composition and cardiovascular endurance can be seen, it is valuable to clarify the detailed physiological effects of long distance jogging with an intensity of 80 percent of max HR, a duration of six miles and a frequency of three days a week for 10 weeks upon various indices and a ratio on body composition and cardiovascular endurance. The purpose of this study is, therefore, to clarify the effects of long distance jogging upon blood lipids, body composition and cardiovascular endurance.

METHODS AND MATERIALS

Fifty three untrained male students were used as subjects. The experimental group including 39 subjects jogged three days a week for 10 weeks with training intensities at 80 percent of each subject's max HR. The training intensities were frequently checked by taking pulse rates in their carotid arteries until they grasped their constant running pace to maintain the intensity. An accurate daily log of the subjects' training was kept and the training was supervised by the author. Training was done on the indoor track at Brigham Young University, U.S.A. The control group consisted of the other 14 subjects who did not perform any additional physical activity for the 10 weeks.

Since it is not easy for untrained individuals

to start running a long distance like six miles (approx. 9.6km), all members of the experimental group started running two milies (approx. 3.2km) a day for the first three weeks, four miles (approx. 6.4km) a day for the next three weeks, and finally six miles (approx. 9.6km) a day for the last four weeks. The progressive program of running was tested in a pilot study which lasted 7.5 weeks, and it was determined that the progressive program was easier for subjects to accomplish. The daily running distance in some people of the experimental group was divided into twice or three times a day, keeping the total distance unchanged. Since splitting the distance of endurance running was effective as continuous endurance running of the same total distance for changing blood lipids, body composition and cardiovascular function as shown in the previous research study[8], and the same data as that study were analyzed in this study, people who split the distance were treated as experimental group members. All of the tests except blood lipids were done at the Human Performance Research Center at Brigham Young University, U.S.A.

The $\dot{V}O_2$ max and max HR were measured by using a treadmill test on a Quinton Model 1844 High Speed Treadmill. Beckman OM-11 and LB-2 analyzers were used to analyze expired air for percentage of oxygen and carbon dioxide, respectively. A high speed gasometer was used to measure the volume of expired air. A IMSAI 8080 Computer System was used to calculate $\dot{V}O_2$ max at 10 liter intervals. The criterion of "levelling off" was used to determine the $\dot{V}O_2$ max. The max HR, measured at the stage for a subject to reach the $\dot{V}O_2$ max, determine by the use of a Quinton Model 740 ECG Computer. All of the subjects were hydrostatically weighed using the procedure of Luft et al.[19]. A DEC 10 Computer System was used to calculate %Fat.

For the 1.5 mile test, subjects were divided into small groups, approximately 10 subjects in each, and instructed to jog/walk this distance as rapidly as possible. Time was measured with a Cronus 3-S electronic stop-watch and recorded as the subject completed the distance. The distance was accurately measured on an indoor tartan track.

Blood samples were collected by a laboratory technician and analyzed for TC, TG, HDL, LDL and VLDL at LDS Hospital in Salt Lake City, U.S.A. All of the samples for pre- and post-tests were taken at the same time of the day following a 12 hours fast.

Barometric pressure and temperature were 643.01 ± 4.28 mmHg and 22.70 ± 0.81 ℃ and 644.86 ± 4.11 mmHg and 21.03 ± 1.16 ℃ in pre- and post-tests, respectively, at the Human Performance Research Center. These values on the indoor tartan track were not measured, but the values seem not to be so various since the track is indoor.

Wood et al.[36] proposed the ratio : HDL/LDL as an atherosclerotic index or more accurately a safety index since elevations of LDL and decreasing HDL have been associated with increasing risk of heart disease. They indicated the ratio were 0.31 and 0.51 in sedentary men and male runners, respectively. The atherosclerotic index or the safety index was detemined in this study. A ratio, HDL/TC, determined by Gerson et al.[10] and Sawada and Karatsu[32] was also calculated in this study. The ratio, (TC-HDL)/HDL, is widely known as an arteriosclerosis index and the value of four or less is normal.[12] The ratio, LDL-HDL, is used as an atherogenic index.[22] These four indices and another ratio were calculated and effects of long distance jogging upon these indices and the other ratio were also indicated in this study.

RESULTS

Results of this study are shown in tables 1 through 8. Tables 1 and 2 present mean and standard deviation values of all variables in the pre-test.

Table 1. Mean and standard deviation values of pre-test data on blood lipids.

	Experimental (n=39)	Control (n=14)
TC (mg%)	161.0 ± 24.1	164.9 ± 37.1
TG (mg%)	86.0 ± 28.1	71.3 ± 31.4
HDL (mg%)	46.2 ± 6.5	50.3 ± 7.0
LDL (mg%)	97.5 ± 21.9	105.1 ± 33.4
VLDL (mg%)	17.2 ± 5.6	14.1 ± 6.4
HDL/LDL	0.50 ± 0.14	0.52 ± 0.15
HDL/LDL	0.29 ± 0.05	0.32 ± 0.06
(TC-HDL) /HDL	2.54 ± 0.67	2.34 ± 1.02
LDL-HDL (mg%)	51.3 ± 23.3	54.8 ± 36.2

where : TC = Total cholesterol
TG = Total triglyceride
HDL = High density lipoprotein cholesterol
LDL = Low density lipoprotein cholesterol
VLDL = Very low density lipoprotein cholesterol

Table 2. Mean and standard deviation values of pre-test data on body composition and cardiovascular endurance.

	Experimental (n=39)	Control (n=14)
%Fat (%)	14.38 ± 4.76	13.00 ± 5.05
Fat (kg)	10.58 ± 4.29	9.21 ± 3.52
LBM (kg)	61.73 ± 6.05	61.66 ± 5.60
Weight (kg)	72.31 ± 8.19	70.87 ± 5.06
$\dot{V}O_2$ max (ml/kg/min)	56.22 ± 6.06	58.27 ± 5.36
max HR (bpm)	199.9 ± 7.1	197.1 ± 8.7
1.5 mile run (min:sec)	11:05.7 ± 1:00.8	11:13.1 ± 1:28.9

where : %Fat = Percent body fat
LBM = Lean body mass
$\dot{V}O_2$ max = Maximum oxygen consumption
max HR = Maximum heart rate
1.5 mile run = 1.5 mile running time

Tables 3 and 4 indicate mean and standard deviation values of all variables in the post-test.

Table 3. Mean and standard deviation values of post-test data on blood lipids.

	Experimental (n=39)	Control (n=14)
TC (mg%)	159.6 ± 23.6	168.7 ± 29.0
TG (mg%)	78.1 ± 38.2	68.1 ± 23.3
HDL (mg%)	48.9 ± 7.4	52.0 ± 8.8
LDL (mg%)	95.2 ± 21.7	103.1 ± 26.6
VLDL (mg%)	15.6 ± 7.6	13.6 ± 4.7
HDL/LDL	0.54 ± 0.14	0.54 ± 0.15
HDL/TC	0.31 ± 0.05	0.32 ± 0.06
(TC-HDL) /HDL	2.31 ± 0.55	2.33 ± 0.81
LDL-HDL (mg%)	46.3 ± 22.0	51.1 ± 29.1

Table 4. Mean and standard deviation values of post-test data on body composition and cardiovascular endurance.

	Experimental (n=39)	Control (n=14)
%Fat (%)	13.17 ± 3.99	13.25 ± 3.77
Fat (kg)	9.61 ± 3.62	9.43 ± 2.68
LBM (kg)	62.43 ± 5.95	61.80 ± 5.18
Weight (kg)	72.04 ± 7.67	71.23 ± 5.16
$\dot{V}O_2$ max (ml/kg/min)	60.87 ± 6.10	58.14 ± 6.01
max HR (bpm)	197.8 ± 4.5	197.8 ± 5.8
1.5 mile run (min:sec)	9:51.1 ± 0:53.0	11:18.3 ± 1:43.2

Tables 5 and 6 show whether or not there are significant differences between pre- and post-tests in both groups. According to both tables, there were significant differences of HDL, HDL/LDL, HDL/TC, (TC-HDL)/HDL, %Fat, $\dot{V}O_2$ max, max HR and 1.5 mile run in the experimental group whereas there was no difference in the control group.

Table 5. T-ratios between pre- and post-test values on blood lipids.

	Experimental (n=39)	Control (n=14)
TC (mg%)	0.5447	0.6754
TG (mg%)	1.3839	0.4511
HDL (mg%)	2.7419**	1.1040
LDL (mg%)	1.0037	0.4511
VLDL (mg%)	1.3924	0.4022
HDL/LDL	2.1650*	0.7775
HDL/TC	2.5940*	0.8810
(TC-HDL)/HDL	2.6634*	1.0410
LDL-HDL (mg%)	1.8707	0.8490

* Significant difference at the .05 level
** Significant difference at the .01 level

Table 6. T-ratios between pre- and post-test values on body composition and cardiovascular endurance.

	Experimental (n=39)	Control (n=14)
%Fat (%)	2.8723**	0.3167
Fat (kg)	1.1959	0.4106
LBM (kg)	1.5479	0.2755
Weight (kg)	0.3241	1.0946
$\dot{V}O_2$ max (ml/kg/min)	5.6246**	0.1143
max HR (bpm)	2.4339*	0.5013
1.5 mile run (min:sec)	10.5851**	0.5761

* Significant difference at the .05 level
** Significant difference at the .01 level

Tables 7 and 8 illustrate whether or not there are significant differences beween the experimental and the control groups in pre- and post-test data. As seen in both tables, there was a significant difference in the 1.5 mile run time in the post-test.

Table 7. T-ratios on blood lipids between experimental and control groups.

	Pre (n=39)	Post (n=14)
TC (mg%)	0.3543	1.0245
TG (mg%)	1.4955	1.1169
HDL (mg%)	1.8558	1.1397
LDL (mg%)	0.7660	0.9664
VLDL (mg%)	1.5547	1.1147
HDL/LDL	0.4220	0.0000
HDL/TC	1.6205	0.5402
(TC-HDL)/HDL	0.6599	0.0827
LDL-HDL (mg%)	0.3262	0.5439

(None of the above T-ratios is significant.)

Table 8. T-ratios on body composition and cardiovasulcar endurance between experimental and control groups.

	Pre (n=39)	Post (n=14)
%Fat (%)	0.8612	0.0618
Fat (kg)	1.1427	0.1900
LBM (kg)	0.0381	0.3640
Weight (kg)	0.7451	0.4271
$\dot{V}O_2$ max (ml/kg/min)	1.1502	1.4083
max HR (bpm)	1.0472	0.0000
1.5 mile run (min:sec)	0.2787	2.9211**

** Significant difference at the .01 level

DISCUSSION

Due to long distance jogging for 10 weeks, HDL, HDL/LDL, HDL/TC and $\dot{V}O_2$ max increased significantly and (TC-HDL)/HDL, %Fat, max HR and 1.5 mile run time decreased significantly in this study. Since the minimal threshold level of training intensity for improvement in $\dot{V}O_2$ max is approximately 50 percent of the $\dot{V}O_2$ max or about 65 percent of max HR,[11] the significant improvement was understandable because each subject in this study maintained 80 percent of his max HR during each training session. The significant improvement in the 1.5 mile run was also understandable because the 1.5 mile run is commonly used to estimate the $\dot{V}O_2$ max.[6]

An increase in HDL after a 10 week training program may have been expected since previous studies[18,34] have show increases of HDL after chronic exercise or a regular traininig program. Since the atherosclerotic index ; HDL/LDL, the arteriosclerosis index ; (TC-HDL)/HDL, the atherogenic index ; LDL-HDL, and the ratio ; HDL/TC, showed significant changes, chronic exercise seems to have favorable influences on the atherosclerotic, arteriosclerosis and atherogenic conditions of the body. Simonelli and Eaton[34] also observed a relative increase in HDL by regular exercise. And they stated that it seems likely that the effects of exercise training in reducing the level of cholesterol transported with VLDL and in elevating that transported within HDL may account for the finding of no consistent changes in total level of plasma cholesterol. Furthermore, Lopez-S[18] indicated that when the effect of exercise is more continuous, such as during chronic activity, the LDL de-

creases, and one has to assume that the synthesis or metabolism of LDL has to be affected in such a way as to render lower absolute concentrations of these lipoproteins. These changes in TC, HDL and LDL seem to be caused by the exercise and to have had favorable influences on the indices and the ratio on blood lipids.

Also since the American College of Sports Medicine[1] indicated that some programs with less participation generally show little or no change in body composition as mentioned previously, participating in jogging with intensity ; maintained 80 percent of each subject's max HR ; distance (a duration) six miles (approx. 9.6km) (two miles [approx. 3.2km] for the first three weeks, four miles [approx. 6.4km] for the second three weeks and six miles [approx. 9.6km] for the final four weeks) ; and frequency three days (every other day) a week for 10 weeks seems to be effective in changing body composition.

The American College of sports Medicine[1] also indicated that the higher the initial fat weight the greater the reduction. However, the mean value of the %Fat, 14.398%, shows a category of lean for men according to the table Cooper[7] shows. The training intensity, the duration and the frequency used in this study seem to be effective although the training period, 10 weeks, may not be so effective since Pollock[29] indicated the programs of an eight to 10 week duration generally result in fewer changes.

It is also understandable that max HR decreased significantly as Scheuer and Tipton[33] and Andersen[2] indicated. Scheuer and Tipton[33] explained that most training studies have shown that max HR can be decreased by training regardless of exercise employed. And they also stated that explanations for the rate reductions during exercise are related to autonomic control, circulating catecholamines, increased stroke volume, or a change in the integrating ability of the central nervous system. Furthermore, Andersen[2] explained that it is more reasonable to relate the reduced max HR with training to an increased pumping capacity, so that even during maximal exercise involving the larger part of the muscle mass there is no need for maximal activation of the cardiac pumps.

From this study, long distance jogging with maintaining 80 percent of each subject's max HR and running six miles (approx. 9.6km) (two miles [approx. 3.2km] for the first three weeks, four miles [approx. 6.4km] for the second three weeks and six miles [approx. 9.6km] for the final four weeks) three days (every other day) a week for 10 weeks seems to be effective to blood lipids, body composition and cardiovascular endurance.

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